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Parthenogenesis in two common species of Collembola : *Tullbergia krausbaueri* (Börner) and *Isotoma notabilis* Schäffer

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Introduction

Reliable records of parthenogenetic reproduction amongst the Collembola are only of recent origin. The observations of STREBEL (1932 and 1938). FALKENHAN (1932), SCHALLER (1953) and MAYER (1957) spoke against the existence of parthenogenesis. The observations of LINDENMANN (1950) of apparent parthenogenesis in *Orchesella cincta* (Linné) and *O. villosa* (Geoffroy) were explained by SCHALLER (1953) and MAYER (1957) as a result of accidential introduction of spermatophores into the culture chambers with the food. After careful drying of the food before introduction into the culture chambers these authors were not able to repeat Lindenmann's observations. CHOUDHURI (1958), however, demonstrated an unquestionable case of parthenogenesis in *Onychiurus parthenogeneticus* Choudhuri. GISIN (1960) synonymised this species with *O. hortensis* Gisin, at the same time mentioning the fact that *O. hortensis* has been found most often in pure female colonies thus suggesting a parthenogenetic mode of reproduction. (The synonymy was not upheld by CHOUDHURI and GOTO (GOTO, 1960)). Facultative parthenogenesis was described in *Folsomia candida* (Willem) and *F. cavicola* Cassagnau & Delamare by GOTO (1960). (*F. cavicola* was considered synonymous with *F. candida* by GISIN (1960)). Later, parthenogenesis in *F. candida* was confirmed by MARSHALL and KEVAN (1962), GREEN (1964), and HUSSON and PALÉVODY (1967). CHRISTIANSEN (1964) mentioned successful, but rare, parthenogenesis in *Hypogastrura matura* (Folsom). HALE (1964) reported a special kind of reproduction in *Onychiurus procampatus* considered as a form of gynogenesis. HALE (1966) observed successful hatching of eggs produced by isolated females of *Tullbergia krausbaueri* (Börner).

In addition to these examples, where parthenogenesis has been reliably demonstrated by successful breeding by isolated females, some records of pure female populations have been tentatively interpreted as results of parthenogenetic reproduction: GRASSÉ (1922) for *Hypogastrura armata* (Nicolet), HÜTHER (1961) for *Tullbergia quadrispina* (Börner), *Tullbergia* denisi (Bagnall), *Folsomides americanus* Denis and *Isotomodes productus* (Axelson) and PETERSEN (1965) for *Folsomia bisetosa* Gisin.

In what follows the records of HALE (1966) for *Tullbergia krausbaueri* will be confirmed, and parthenogenesis in *Isotoma notabilis* will be demonstrated in contradiction to the results of SHARMA and KEVAN (1963) who found that isolated females of *Isotoma notabilis* Schäffer from Canada produced eggs but who rejected parthenogenesis in this species because the eggs did not hatch. Both species are amongst the most abundant Collembola of Europe and occupy a very wide range of habitats.

Materials and Methods

Parthenogenesis has been demonstrated in *Tullbergia krausbaueri* and *Isotoma notabilis* by rearing individuals, isolated since the egg stage, in laboratory cultures at a constant temperature of 15° C. as a by-product of an investigation of life-histories and growth in a number of Collembola species. The culturel stocks of *T. krausbaueri* originated from the Danish IBP beechwood research site, Hestehave wood, E. Jutland, a homogeneous monoculture of c. 85 year old beech trees on a mull soil. Those of *I. notabilis* originated partly from this area and partly from a treeless grass-covered gully in sandy soil near the Molslaboratory. From stock cultures of c. 20 to c. 200 individuals; eggs were collected after chorion rupture and transferred to culture chambers described elsewhere (PETERSEN, in press). The cultures from the grass-covered gully were given dried brewer's yeast as food, while the food given to the Hestehave wood cultures was a yeast, *Candida* sp. 1 (kindly supplied and provisionally determined by professor Vagn Jensen, The Royal Veterinary and Agricultural College, Copenhagen), isolated from the wood soil and cultured on agar plates. Great care was taken to sterilize the needle used for handling the cultures in a flame every time before it was introduced into a culture chamber, to avoid transfer of microorganisms and spermatophores. The cultures were mostly examined every 2 days, or at least twice a week.

Results

Tullbergia krausbaueri: (Table I). 7 specimens were separately isolated from the time of hatching. 1 further specimen, from a culture where 2 individuals hatched but where only one remained shortly after hatching, was included in the material. Only one individual, which died before the normal time for first egglaying (32-40 days) did not produce eggs. The others produced from 7 to 58 eggs each during life spans of 54 to 206 days. 62 of a total of 217 eggs were observed for a sufficient long period for hatching to have taken place. 44 or 71 % did hatch, 11 or 25 % of which were followed to first egglaying. The high egg mortality was probably due to injury sustained in transfer from one culture chamber to another, or to inappropriate conditions in the culture chambers. The hatching success did not appear to be greater for eggs derived from cultures of many individuals.

In *T. krausbaueri* single individuals breeding lines were followed until the successful hatching of a 3rd parthenogenetic generation.

In the material of *T. krausbaueri* from the Hestehave wood only females have been found so far but a large material of 1 1/2 years monthly samples still remains to be examined and may well reveal males since apparently other populations of *T. krausbaueri* have both sexes represented. An examination of the material from an investigation of the Hansted Reserve in NW Jutland (PETERSEN, 1965) showed the presence of males, although they were less abundant than females.

Isotoma notabilis: (Table I). 3 individuals from the Hestehave wood, and 21 from the grass grown gully at Mols, were kept isolated since hatching. 2 more cultures from the wood and 1 from the gully, where 2-3 individuals hatched but where only one remained shortly after hatching, were included in the material. 13 of these individuals produced from 1 to 40 eggs during life spans of 20 to 157 days while 14 did not produce eggs. The development of 71 of a total of 144 eggs was recorded. 45 or 63 % of the eggs studied hatched, 16 or 36 % of which were followed until first egglaying. The same considerations as to egg mortality mentioned above for *T. krausbaueri* are also valid for *I. notabilis.*

In *I. notabilis* single individual breeding lines have been followed through 13 months until the successful hatching of the 6th parthenogenetic generation.

TABLE I

Fate of eggs produced by isolated females

	T. krausbaueri	I. notabilis
Number of females recorded	8	27
Number of females producing eggs	7	13
Mean observation period (days)	128	78
Total number of eggs	217	144
Number of eggs recorded for development	62	71
Number of hatched eggs	44	45
Number in new generation producing eggs	11	16
Number of eggs which fail to hatch	16	26

Males of *I. notabilis* have not been found either from the beech wood or from the gully, whereas a large number of females have been determined. However, in this species sexing of individuals is often difficult, because the furca covers the genital aperture, and therefore some males may have been overlooked in the material. As in the case of *T. krausbaueri* a large material from the Hestehave wood still remains to be examined.

Discussion

The ability of females to reproduce successfully as isolated individuals without chance of contact with spermatozoans, as demonstrated in the present study indicates parthenogenesis in the two abundant species of Collembola *Tullbergia krausbaueri* (Börner) and *Isotoma notabilis* Schäffer. For *Tullbergia krausbaueri* the results are in accordance with Hale's observations on a population from a moorland habitat in the Pennine Mountains of Britain (HALE, 1966), while the observations on *Isotoma notabilis* are in disagreement with the statement of SHARMA & KEVAN (1963): « Thus, although unmated females will oviposit, there is no evidence of parthenogenesis in this species ». The conclusion of SHARMA & KEVAN might be fortuitous, which is not unlikely considering the high mortality of eggs in the present study. On the other hand this mortality did not appear to be greater for eggs derived from single individual cultures than for eggs from cultures containing many individuals. The different conclusions might also be due to seasonal cycling in the ability to reproduce parthenogenetically, or to genetic differences between the two populations, and might be evidence for confirming the separation of the North American form, described as a separate species *Isotoma eunotabilis* by Folsom (in MILLS 1934 and 1937), from the European *Isotoma notabilis.* STACH (1947) placed the two forms as two geographical races of *I. notabilis.*

HALE (1966) did not describe the sex distribution within the Pennine moorland population of *T. krausbaueri.* The only record of sex-ratio in *T. krausbaueri* populations known to the author has been given by HÜTHER (1961) who found that the percentage of males to females in different populations varied from 17.7 % to 2.6 %. As mentioned above, populations of *T. krausbaueri* from N. W. Jutland included some males, but less abundantly than females. In the Hestehave wood population no males have been found so far. For *I. notabilis* there is the same lack of records of sex distributions, but apparently, although not directly mentioned, the population investigated by SHARMA and KEVAN (1963) included both sexes. No males have yet been found in the populations investigated in this study. For both species further information on the sex distribution in the populations is required before the parthenogenetic reproduction found can be referred to as facultative or seasonal or obligatory. The populations investigated may form obligatory parthenogenetical strains of the species also known elsewhere in bisexual populations.

SUMMARY

Laboratory culture studies reveal parthenogenetic reproduction in one population of *Tullbergia krausbaueri* (Börner) and in two populations of *Isotoma notabilis* Schäffer. No males have yet been found in the field populations from which the laboratory animals investigated were taken, whereas males apparently exist in at least some other populations of *T. krausbaueri.*

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